Influence of Exploitation Damage on the Capacity of Scaffolding Frame Standards

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Abstract

The following paper presents numerical analyses and laboratory tests used for analyzing the impact of exploitation damage to the main structural members of the scaffolding frame system. The presence of inevitable defects reduces the strength of material compared to the theoretical strength. Numerical analysis preceded by own laboratory research allows you to describe precisely the behavior of the element. Performing a series of calculations allows you to obtain information about the impact of the size and location of the damage on the bearing capacity of the scaffolding frame.

Keywords: nonlinear static analysis, scaffolding, steel pipe, structural defects

1. Introduction

Exploitation damage of scaffoldings can be divided into several groups. First one consists of the defects of negligible importance, which are reducing only aesthetic values of the scaffolding. Others, such as the absence of a pin on the rail bolt, are local faults that do not affect the capacity and stability of the entire structure, but are very important for safety of users. The most important group are the damage to the main structural components that cause the decrease in strength of the scaffolding components and hence the whole structure. Among them the most dangerous is deformation of the cross section of the scaffolding elements. Numerical analyses showing the influence of this type of damage were shown by the authors in the paper [1]. Another defect that has a great impact on the scaffolding capacity is the deformation of the structural element's axis. The paper presents analyses that take into account this type of damage. The location of the defect is very important. This issue turns out to be more important than the magnitude. The damage to the standards of the frame of the façade scaffolding system is much more important than to the lower bar or to the profile on which the platforms are based. This is due to the fact that the standards are the most stressed part of the scaffolding. The position of the defect on the standard is also significant.

2. Laboratory tests of the frame of the façade system

Laboratory tests are the basis for the verification of the created models. A special test site was built in which a specially prepared steel plate with spindles was screwed to the base of the press on which the examined element was pulled over. This allowed for the same alignment of all tested elements centrally under the load-bearing crossbar, and accurately reproduced the attachment of the element in the actual scaffolding structures. The load was transferred to the tested element by means of a horizontal beam pushed onto the frame pins. The test site with the assembled test item is shown in Figure 1.

Figure 1: Test site for loading of the frame of the façade scaffolding system

Figure 2 shows the measuring equipment used during frame testing. On each of the standards in the middle of the height, a set of four electro-resistive gauges measuring the strain in the vertical direction was mounted with use of glue. In addition, a set of two sensors measuring horizontal displacement was mounted on one of the standards. All sensors mentioned above were control points used in verification of the numerical models.

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All results including forces were recorded using a Hottinger signal analyzer.

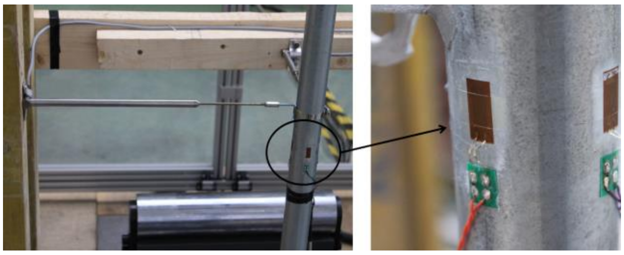

Figure 2: Displacement sensors and strain gauges on a frame standard

3. Numerical analysis

Calculations were made with use of Autodesk Simulation Multiphysics. Shell elements from the finite elements library were used to build the model of the frame. Beam elements were used to model the beam that conveyed the load from the press to the frame standards. Nonlinear static analysis with geometric and material nonlinearity was used for the calculations.

3.1. Material and load models

A linear hardening model was adopted for the calculation. The load in the model was controlled by linear displacement.

3.2. Boundary conditions

Initially in the model there were used supports blocking the movements and allowing free rotation at the ends of the standards, but after the first analysis, it turned out to be a mistake. For the non-damaged reference element the force obtained from such calculations was almost twice less than that obtained during the test. In addition, the form of the item destruction for the example presented below with the joint supports applied was different. Adoption of full constraints yielded with the results much closer to the ones obtained from the tests, but a higher destructive force was obtained from the calculations. This forced the use of flexible supports at rotational degrees of freedom.

4. Comparison of results

The diagrams presented in Figure 3 show the strength-strain relationship of one of the examined elements in which the damage introduced was bending of one of the standards in the plane of the frame. The continuous line indicates the results obtained from four strain gauges during the test and the dashed line represents the respective values read from the numerical analysis.

As it can be seen, there is a very good compatibility of obtained results, i.e. deformations in control points such as places of strain gauge application. This shows that the parameters of the analysis and of the model are accurate. However, the most important is the compatibility of the resultant destructive force. This parameter determines the impact of a given damage on the frame's bearing capacity. In this example, additional calculations were carried out with the similar shape of the defect but with 90 degrees rotation about the axis of the standard. As expected, a lower destructive force was achieved. The value was almost 20 kN lower, which shows the importance of the positioning of the defect on the frame.

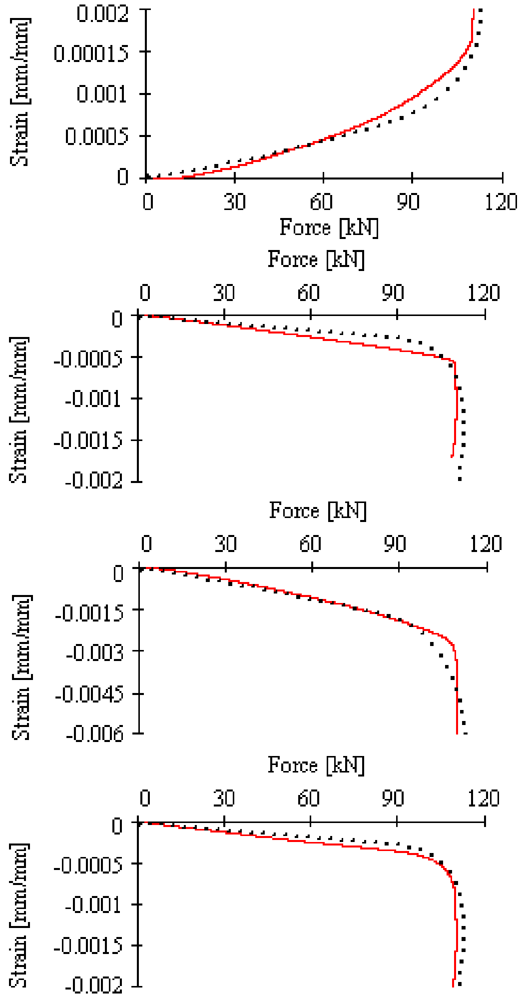

Figure 2: Strength-strain relationship

5. Conclusions

Laboratory research carried out on real components eliminates errors in assumptions when creating numerical models. Having a verified scaffolding frame model, a number of analyses can be carried out with great ease to obtain information on the effect of exploitation damage on the bearing capacity of the frame. It is obvious that lowering the bearing capacity of a frame depends on the size of the specific defect, although the relation is not linear. Attention should also be paid to the location of the defect on the frame, because the same amount damage in different locations may have a different impact on the capacity.

References

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